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BREEDING FOR DISEASE RESISTANCE IN PLANTS¹

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Our common asparagus (*Asparagus officinalis*) was cultivated in America from the time it was introduced from Europe until 1896 without any losses from disease worthy of record. The varieties in general use were then of American origin and had been developed for qualities other than disease resistance.

Asparagus rust, a disease due to the parasitic fungus *Puccinia asparagi*, was discovered in New Jersey in 1896, and within six years had spread to the Pacific coast. This rust proved very destructive; asparagus fields were killed within a few years. Attempts to control it by spraying or other preventive and sanitary measures were unprofitable, and the outlook for asparagus culture was for a time very gloomy.

It was observed that some varieties, such as Argenteuil and Palmetto, were partially resistant. An organization was formed to develop a rust-resistant asparagus from numerous varieties of asparagus imported from foreign countries, and the breeding work was placed in charge of Mr. J. B. Norton. Among the imported varieties was one from England, named *Reading Giant*, which was more rust-resistant than any other. This was variable in type as well as in resistance, but selected individuals pollinated by selected male plants of this and other varieties have given rise to races of asparagus which are almost immune to rust and are at the same time of superior size, quality, and productiveness (1).

The problem of asparagus rust control was thus solved within five years. It remained only to disseminate the new resistant varieties.

¹ Invitation paper read before a joint meeting of the Botanical Society of America and the American Phytopathological Society at Pittsburgh, December 31, 1917.

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Meanwhile a development of great biological significance was taking place. The old beds of susceptible American asparagus were killed out or plowed under as the weakened plants were no longer profitable, and replanting with Palmetto, Argenteuil, and Reading Giant was generally practiced throughout the eastern districts. At the same time the rust became less prevalent, except where infection centers of uncut, susceptible asparagus were permitted to remain. The elimination of the old non-resistant kinds is proving to be nearly as important as the introduction of the new resistant stocks.

We shall shortly be on the same basis as Europe, where asparagus and its rust parasite are both native, and where no serious losses occur since asparagus highly susceptible to rust has been eliminated. This fortunate result, which has taken place during our time and under our eyes, illustrates the fundamental principles which should guide our work with other crops, to the end that American agriculture may be protected against excessive losses from plant diseases.

Disease resistance in plants, as in animals, is nature's method of restricting parasites. Nature has been breeding disease-resistant plants since the world began. Evolutionary factors tend to modify the toxin formation of parasites and to build up the resistance of the host plants. Organisms react in this way upon each other throughout the range of their natural geographic distribution. The principal barriers are the seas, and we must therefore lay much emphasis upon the *intercontinental* relations of this problem of disease resistance. The native parasites of our native plants, growing in their natural surroundings, offer no parallel to the ravages of introduced pests.

The most serious plant diseases are, in all countries, due to the bringing together of a host and a parasite native to different continents. When our forefathers cleared away the American forests and planted the European pears, the pears were ravaged by blight, *Bacillus amylovorus*, an endemic parasite of American pome fruits, which are, however, very resistant. Countless attempts to introduce the European grape, *Vitis vinifera*, into the eastern United States have failed because of the Phylloxera, black-rot and mildew, all native here; yet these diseases present a relatively slight obstacle to the culture of American species of grapes. The ravages of these diseases when carried from America to Europe nearly wiped out the viticulture of Europe, and they were checked mainly by the use of resistant American stocks.

The American gooseberry mildew, *Sphaerotheca mors-uvae*, is now repeating this history on the gooseberries of Europe. The late blight of potato and hollyhock rust are from South America, chestnut blight and citrus canker from Asia, white pine blister rust from Europe. In each case it is to be expected that resistant forms will be found to occur where the disease is native. This has in fact already been shown to be true, a recent and notable instance being that of the Chinese and Japanese chestnuts, which Dr. Van Fleet is using to cross with the American chestnut to produce a better and resistant tree.

The disease-resistance factor is important in all breeding. In some cases we may select directly for resistance from races of established quality. The wilt disease of cotton, due to the vascular parasite, *Fusarium vasinfectum*, occurs very commonly in the sandy soils of our cotton belt, from North Carolina to Texas, rendering cotton culture impossible on millions of acres. This disease has been overcome by the selection of resistant plants from fields where the disease had eliminated all others.

The cowpea suffers in the same area from a related parasite, *Fusarium tracheiphilum*, to which all varieties are subject except the Iron and its derivatives, Brabham and Monetta. That these cowpeas are also resistant to root-knot is most remarkable, considering that the nematode, *Heterodera radiculicola*, has several hundred hosts, and that cowpeas, as a class, are very susceptible.

To produce a wilt-resistant watermelon it was necessary to hybridize with the hard-fleshed citron, and while good melons have been secured a fully satisfactory combination of resistance with quality and a rough rind for shipping has not yet been obtained (2).

Working to combat a related disease of cabbage, due to *Fusarium conglutinans*, Professor L. R. Jones has employed the same method of selection with great success. Cabbage yellows will no longer be feared when these new varieties are disseminated (3).

The *Fusarium* wilt of tomato, *Fusarium lycopersici*, a destructive disease in our central and southern states, is yielding rapidly before the plant breeder. The recent tests of F. J. Pritchard, of the Bureau of Plant Industry, show that a resistant late tomato has already been secured and that satisfactory early varieties are in sight.

The strains of flax resistant to *Fusarium lini*, bred by Bolley (4) and others make possible the continued culture of this important crop in regions where it was being abandoned because all the land was infested with the wilt parasite.

Equally remarkable are the results of James Johnson (5), who has selected strains of tobacco resistant to *Thielavia basicola*, a root parasite of many species and varieties of plants.

It is especially fortunate that resistant varieties may be employed against these root parasites which cannot be reached by fungicides or eliminated by rotation.

The problem now before us is to produce adapted races, resistant to disease, and bring them into general cultivation. There is reason to expect that when such a wheat as the Kanred, just described by Melchers, is in state-wide cultivation, stem rust will become insignificant in prevalence.

All plant breeding should take disease resistance into account. Strains under test should be exposed to infection by all the parasites that they are likely to meet in order to bring them into equilibrium, for it is possible by breeding plants in the presence of their diseases to produce resistant varieties. Such resistance will be reasonably permanent, at least as long as admixture and intercrossing with other non-resistant varieties are prevented.

There will, however, be serious danger that the advent of a new parasite, or even of a new biological strain, would result in losses. Such introductions, as we have seen, will be from other continents. Consequently, there is a fundamental biological argument for a policy of exclusion from North America of all living plant material from other continents, or at least for strict regulation and admission under safeguards as to disinfection.

International commerce has developed enormously in the last generation. Plant products may come from the ends of the earth; corn and potatoes have come from Australia, fruit from South Africa, and beans from Manchuria. These food products are to some extent a source of danger, since they may bring in new parasites; but the importation of nursery stock is a greater risk, for living plants are constantly accompanied by parasitic fungi and insects.

Complete success in excluding plant diseases is perhaps not to be hoped for, when one takes account of the myriad articles of commerce which may carry infection, such as wool, hides, and lumber; nevertheless, asparagus rust was not brought over until about 1896, chestnut blight not until after 1900, and citrus canker not until about 1911. That these diseases were kept out for so long when we had no exclusion law argues strongly for a hopeful view of the future.

If commerce in living plants is so dangerous, what view shall be taken of governmental plant introductions? The Office of Seed and Plant Introduction brings in seeds and plants from all over the world in small lots of a few seeds or buds each of thousands of species. If these introductions can be kept free from disease, and they have been thus far, they will be of invaluable assistance to the breeder. The great need is for a better organized use of this plant introduction service to bring in not only all the varieties of a crop but all its relatives that can be crossed with it, and, after propagation in a quarantine station, to place them at the disposal of breeders.

The improvement of our staple crops itself requires co-operative organization to conduct on a broader scale with ample material the work now attempted in an individual way. There is need of more systematic foreign exploration by specialists on the crops to be bred, who should in all cases be accompanied by pathologists to study the diseases that occur in the regions from which introductions are contemplated, and to assist in the collection of disease-free material. Foreign testing and propagation stations are also needed, the last to insure the sending of material free from insects and diseases.

LITERATURE CITED

1. **Norton, J. B.** Methods used in Breeding Asparagus for Rust Resistance. U. S. Dept. Agr. Bur. Pl. Ind. Bull. **263**. 1913.
2. **Orton, W. A.** The Development of Disease-resistant Varieties of Plants. *Conférence Internationale de Génétique* **4**: 247-265. Paris. 1911.
3. **Jones, L. R., and Gilman, J. C.** The Control of Cabbage Yellows through Disease Resistance. *Wis. Agr. Exp. Sta. Res. Bull.* **38**. 1915.
4. **Bolley, H. L.** Flax Culture. *N. Dak. Exp. Sta. Bull.* **71**: 212. 1906.
5. **Johnson, James.** Resistance in Tobacco to the Root-rot Disease. *Phytopathology* **6**: 167-181. 1916.